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OUR FRESH-WATER ALGÆ.[1]

BY EDWARD S. BURGESS.

WHAT do you mean by the Fresh-water Algæ? and what interest do you find in them? are the questions I find asked me. Go with me to the coast, if you would learn my answer. Notice the sea-weed growing along the shore; see the dark olives and browns shown in the rockweed, left dripping and slippery by the retiring tide; note the waving tufts of green laver and sheets of membrane-like sea-lettuce floating near the tide-mark, and watch the beautiful red mossy cushions of delicate growth washed in by the breaking wave. Ask of almost any dweller on the coast and he will say, "People nowadays call them algæ." The longer you watch them the more attracted by their beauty you will become; soon you will begin to collect and mount them like other visitors to the shore. At first the most beautiful only will be collected; then others that are less so, "simply for the variety," as you may apologize to yourself; finally you will end by determining to keep a specimen of every kind, whether beautiful or not. And now you approach the stand-point of science, for science sees interest in every representative of a race, whether that race be high or low; and finds in every plant a right to our regard in the fact of its inheritance of the mystery of life.

But every summer must have its end, and so there will come the time of packing up the glowing specimens with their endless shades

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of reds and greens and olives. With the return to the interior the desire rises to expression, "Would that the inland waters contained such treasures as these mosses of the sea!" It is the old story, the wish is father to the thought, and the thought will perchance come to you, that perhaps they do; why should there not be mosses in the lake and river, brook and clear spring, as well as in the brine? and you resolve to look for yourself on your return, or you ask some one who knows to tell you if there are not also algæ in the inland waters. "Yes, certainly," he replies, and you then inquire, "Why is it then that I have never seen them?" to be reminded in turn that it is not the first time the eye has been awakened to perception of the beauties round its home by travels in a foreign land. Besides, the algæ of fresh-water are smaller and less conspicuous than those of the sea; many are microscopic, and many others are, when taken singly, but just visible to the naked eye. They are less varied in color as well, and so it has happened that many collectors know the sea mosses first, and if knowledge of the algæ of fresh water comes at all, it comes as a derivative from the other.

To compare the actual organs of the alga and the flowering plant, we remember that the flowering plant is adapted to land-conditions, securing nourishment from the air by its leaves and from the soil by its roots. The alga is adapted instead to water conditions and has no leaves nor roots for procuring nourishment, but absorbs through its general surface. The alga may or may not have root-like bodies (rhizoids), or a root-like base (a disc or hold-fast), but if present, these are simply to fix the plant in position. Presence of distinct stem and branches is optional with either. Most flowering-plants produce leaves; most alga do not; those leaf-like bodies which are produced, as by the Sargassum or Gulf-weed, are called phylloids; these do not occur in the strictly fresh-water species. As its name indicates, the flowering-plant is to produce flowers, and from them seeds containing an embryo of one or more seed-leaves (cotyledons). Alga produce no flowers and seeds, but instead, as a usual rule, spores. Their spores resemble seeds in appearance and in function, but contain no embryo and differ in details of development. The alga is thus the less specialized, the more simple, the lower in the scale of creation. Instead of delegating the functions of plant-life to separate portions of itself as

organs, the alga often combines them all in a single cell or ultimate constituent. In cases where the alga is composed of many cells the same principle often holds good, each cell being sufficient unto itself, uniting within its own small limits all the multifarious employments or functions which make up the life-activity of its species, and therefore able to live equally well if by accident it becomes detached from its associated cells. Hard-working cells are these, for they have not yet learned the rudiments of the division of labor; cells of manifold activities certainly, and correspondingly hardy, self-dependent, and ever unsubdued. They live and replenish the earth unseen by man, till by effects or masses of individuals they move him to wonder, and, as in the middle ages, to ascribe their sudden-seeming presence to the wrath of heaven or the agencies of the black art or to the medium of alchemy.

The present needs will not permit my entering into the subject of the scientific classification of the algæ, but it may be of service to notice some of the principal groups for which common names are in use. According to habitat we may divide all algæ into the marine and fresh-water divisions, including with the latter the ærial species, surface-dwellers on moist earth, sand, rocks and trees. Recombining all the algæ, they may be again divided according to coloring matter, contained, generally as a liquid, in their cells, classing them therefore as the red, olive and green algæ, and fourthly as the Phycochroms, the last having as their characteristic a bluish cast seen in the green, ashen or grayish hue which pervades them. The red algæ, so prized by collectors on the shore, are scantily represented in our inland waters; the olive do not appear at all; but the two other divisions find in fresh-water their chief representation. The green algæ of the tide-marshes along the coast are very conspicuous, and of uncounted numbers, but of very few species comparatively; those of fresh-water are probably still more abundant in individuals, certainly in species. The Phycochroms never reach as great a size as do members of each of the other sections; they are, indeed, chiefly microscopic, as individuals, if not as masses or colonies. Their cell-contents are also less highly organized. Their chief abode is in slowly running streams and quiet waters. They are the Cyanophyceæ of Goebel and of various authors since Nägeli, in 1849. They are remarkable for the pres-

ence of a beautiful blue coloring matter, phycocyan; and for the fact that no sexual modes of propagation have been discovered in them; nor, at least with rare exceptions, is there any evident nucleus, or central denser protoplasmic body, in their cells, such as is the rule elsewhere among plants.

Multiplication in the algæ takes place in either of several ways; the most common is that of fission, as in the multiplication of cells in a flowering-plant, where each cell divides into two parts, each a perfect whole like its parent. The two parts gradually increase in size until they reach their full degree, then themselves divide again, and so on. They may or may not remain attached to each other. Another mode of algal multiplication is by budding (gemmation), where the bud-like protrusion which grows into a new cell remains usually attached to its parent. A modification of this, prolification, consists of numbers of new cells arising from the side or end of the old, as if intended to become a separate individual, but often long adhering to the other, as if an attached child unwilling to remove from its parent. Some algæ, as the Caulerpa, rely on this method for their chief mode of propagation, as do so many of the higher plants upon "spreading by the root" in place of production of seed.

Another curious modification of budding is common in the red algæ, the production of tetraspores, bodies which are formed by division of a cell into four equal parts, each of which becomes a spore, able to grow into a new plant, and thus analogous to the bulblets produced by tiger-lilies and some onions.

Other algæ are reproduced by sexual methods, producing spores in some part of the process. Among the most remarkable of these are the zoospores, small seed-like bodies, usually soft and oval, sometimes spherical, tipped with one, two or more waving threads (cilia), which lash the water and carry the spore onward in the current thus produced, sometimes with great velocity and sometimes for several hours. The cilia finally fall off and the zoospore comes to rest; and if favorable conditions have befallen it, it has effected a lodgement on some resisting substance, there to begin to lengthen, divide into cells, and grow into a new plant. During their motile stage these little spores seem like so many little green animalcules darting about; so indeed they were long thought to be; and their names still perpetuates this idea, the word zoospore meaning "animal-spore."

Another kind of spore, motionless, unlike the preceding, the zygospore or "yokespore," is produced only as the result of two cells uniting and fusing their contents, the confined mass becoming the zygospore. This process of coalescence, known technically as conjugation, occurs in the beautiful Desmids, algæ so distinct as to form a group by themselves and therefore not now to be entered upon. The process also occurs in the Spirogyras and their relatives common in conspicuous green masses in still waters, each mass composed of long threads tangled together which shine with silky lustre when taken out of the water giving them their English name of silkweeds. These spores are smooth or spiny, often studded with knobs or branching thorns; they have a thick, hard case, resisting the drouth of summer and the cold of winter, enabling them to await their proper time of growth in safety. The zoospores are liable to confusion with certain green infusoria among animalcules, the zygospores with certain similar unicellular algæ as species of Acanthococcus, now thought to have been often mistaken in this country for desmid zygospores.

A very curious kind of reproduction is that of the Vaucheria and its allies, the production of "oospores," which resemble zygospores in their resting-period and in their hard, shell-like case, but differ in formation. And if with Goebel we include the Charas among the algæ, we are presented by them with still another mode of reproduction, the formation of "nucules" or nutlets, dark or red, often strikingly handsome to the naked eye when abundant in their little clusters on the green feathery plant, each nucule surrounded by its little involucre and itself chased as if by chisel with a spiral line winding many times round it.

But perhaps the most complicated of algal systems of reproduction is that of the red algæ, to be observed in fresh water in the Batrachosperms, Lemaneas, etc. It may be called the cystocarpic system, its result being the formation of a fruit or cystocarp, filled with spores, often reminding one of the grains in a pomegranate or the seeds in a water-melon, and sometimes still more regular in arrangement. Remembering the sexual system as developed in flowering-plants requires, previous to the formation of seed, the presence of the stamen and the pistil, respectively the male and female elements; we look for their counterpart in these plants, and

find it in the presence respectively of antheridia and archegonia. In the violet batrachosperms of fresh water these organs are produced on separate individuals. The antheridia contain small motile bodies, antherozoids, analogous to the pollen contained in the anthers of flowering-plants, and to the spermatozoids of animal life. These antherozoids find their way upon the other plant to where a long hair-like tube (the trichogyne) opens, through which their fertilizing influence reaches the protoplasm mass in the bulbous base of the tube (the archegonium or carpogonium). The protoplasm on fertilization swells, divides, usually forms new cells around it, as if walling itself in, and then a series of new cells within, many of which become spores, the whole fruit so formed becoming as full of spores as a stramonium pod of seeds, and generally resembling the latter in their position as well.

There is great variety of form among the algæ of fresh water, even among the unicellular species. It might be thought that these species, where the whole plant is composed of but a single cell, would present little variety; especially when it is considered that such simple cells commonly float loosely in the water, and in situations enabling the supposed normal spheroidal cell-form to develop itself, free from the influences of crowding or lateral stimuli. But not so simple is the plan of nature, and a great range of shape exists among the single-celled algæ, from the spherical of the common protococcus of our trees and walls to the bur-like spiny Polyedrium. For instance, one Rhaphidium is crescent-shaped, another needle-shaped, another unicellular algæ is shaped somewhat like the letter S, another like a J, another a C. The Botrydium is balloon-shaped, the Chytridium often urn-shaped, others appear as little discs, others ellipses, others cubical or pentagonal. When associated in masses, pressure and the exigencies of growth change the shape of those naturally circular into irregular polygons. Some species of Ophiocytium grow into curious coils; some Polyedriums are exact triangles, others take the form of a Greek cross. Extend our view to the desmids and diatoms, which are also of the unicellular algæ of fresh-water, and the number of cut and fantastic forms which a plant of a single cell may present, becomes indefinitely increased.

The larger number of species of the fresh-water algæ are, however, of more than one cell. Of these multicellular algæ some grow

into discs, as Coleochæte, some expand into a leaf-like membrane, as Prasiola, or widen from hollow spheres and tubes into broad undulating sheets like the Tetrasporas, others grow in solid globular masses, as the Chætophoras, one species of which occurs in the form of little green balls like peas, and hangs on dry grasses and other supports in quiet pools in spring. Others of looser texture, expand into an indefinite and irregular mass which will crumble at a touch, or form a gelatinous stratum which slips like oil through fingers that endeavor in vain to raise it from the water. Many others become firmly adherent crests on rocks, especially under falling water. Most of the more beautiful species become filaments, usually formed of cells placed end to end, sometimes composed of several or many such filaments bound together, either branching or not, and attaining particularly fine development in the Batrachosperms, where the many branched and forking filaments are clad with radiating whorls of smaller branches, often in the most perfect regularity.

Very commonly gelatinous in substance, many of the larger species are too frail to bear lifting out of the water, and yet endure considerable stress of their native current without harm, swaying with graceful motion as becomes beings born to the water. As there are all degrees of consistency in jellies, so there are in algæ, from the tough jelly of a Prasiola, to the fluid jelly of a Tetraspora. Professor Wood named his genus Pagerogala, "frozen milk," from its seeming to float like white curds of clotted milk in a Pennsylvania spring. Some Draparnaldias may fairly be called succulent, others approach nearest of any of our algæ to the wiry character; the Lemanea is sometimes almost leathery; Spirogyras feel under the fingers like a lock of hair; some of the largest Confervæ are tough enough to support considerable weight, and have such strength of fibre that German ingenuity has tested their capability for textile use, and not only made mattress-stuffing and paper from them, but actually fabricated them into coarse trowsers, as if to show that the common phrase "clad in weeds" is not incapable of the most literal of fulfilments. Stranger still than any Confervæ, are the mailed knights among the algæ, the little diatoms, absolutely unyielding and encased in silex, like so many little glass boxes under the microscope all curiously chased and set with flashing points and knobs. Some of

the Charas secrete instead of silica, a sheath of carbonate of lime about themselves, until the whole plant seems a succession of joints of stone, or links of white lime, giving it its popular cognomen of stonewort.

The colors of our fresh-water algæ are varied to a degree that may surprise the student who expects only green. There is considerable variety even in their green, from the usual grass-green of the Spirogyras to the pea-green of some Palmellas ; the little "water-flower," so to render its name, *Anabæna flos-aquæ*, is a verdigris-green ; *Chlamydomonas hyalina* is called by Wolle a milky-green. Many shades of red are found, vermilion in Chlamydococcus, scarlet in Thorea, blood-red in *Glœocapsa sanguinea*, amethystine in *Leptothrix tinctoria;* Hildenbrandtia is often purple, one of the Chantransias is rose-purple, a Lemanea is violet ; species of *Chroölepus* range through ash, yellow and orange to golden-red ; Tuomeya is said to be olive-colored, Hydrurus ochre ; some Vaucherias are brown, one Glœocapsa is black ; a Leptothrix is straw-colored, another fawn, a Chantransia steel-blue, a Cylindrocapsa pearly. Many preserve their color when dried ; others change, some simply by fading to a lighter shade of their previous color, others to a new tint ; one Batrachosperm is described as at first of a mouse-gray color, then yellow, and on drying, violet ; *Chantransia macrospora* and Thorea are, when living, dark green, but dry a beautiful purple-violet ; the Sweet Chroolepus is tawny when fresh, changes to an ashen-gray and finally greenish ; a kindred species is reddish-orange when olive, light yellow on drying ; *Zygnema purpureum* changes from yellowish-green to dark purple ; *Lyngbya tinctoria*, says Wolle, from purple to violet steel ; *Vaucheria dichotoma* may stand as type of the change so frequent in the higher plants, from green to brown. Many algæ unite several colors at the same time ; almost all do so when we compare the spores with the vegetative growth ; a remarkable instance of variegation in vegetable growth alone is seen in a new Lyngbya found by Wolle in the Lehigh at Bethlehem, Pennsylvania, waving in tufts six inches long, "the extremities bright-blue green, lower parts changing to yellow-brown ; and at last fading out to a colorless base."

Few of the odors possessed by the algæ have received a name. Out of the 1300 species recorded in this country by the Rev.

Francis Wolle, there is perhaps but one which has an odor remarkably offensive: this, the Hydrurus is, however, so unpleasant that the Dane Lyngbye remarked of it seventy years ago that "it could be endured only by an algologist." Bory called attention early in this century to "the most peculiar odor" of Lemanea when burned. Extend the view to the Charas, and to the diatom Schizonema, and a number of species of imitating or unpleasant odors are met; but the number of algæ which are in themselves possessed of much odor of any kind is few. If any persons associate disagreeable odors with the algæ, it is doubtless from confusing the odor of a place with that of an alga happening to be at the time its resident. Nor are the algæ without examples of exquisite fragrance; man might not have thought to look here for the sweetest odor, but Nature has not forgotten to add that charm to some of these, her lowly children; one of them *Chroölepus odoratus*, has been known in Denmark for over seventy years as the "sweet conferva"; it grows also on the bark of shade trees along highways in Pennsylvania. Perhaps more interesting still is the fragrance of the violet-moss, *Chroölepus iolithus*, which attracted the attention of Linnæus almost a century and a half ago; it grows as a thin glaucous, green or reddish-orange layer over stones in the Alps and in our own country in the White Mountains, causing them to "give forth a strong odor of violets." The Swiss are said to carry these stones home and by occasional moistening, to renew the odor from time to time. These Alpine people call it "Veilchen-moos" and the "Veilchen-stein"; and this latter was adopted as its name in science by Linnæus, for the specific name he gave it and which it still bears, is to be translated *Violet-stone.*

The size of our fresh-water algæ has been already referred to as commonly microscopic; yet there are many of considerable dimensions. About Washington we have Tetrasporas growing a foot long, beautiful undulating sheets of translucent green floating out on flowing water; some of our Cladophoras are still longer; and the sac-like Water-nets and the string-like Confervæ equal or exceed them. Any locality may yield however, for one specimen of six inches, a score of but one inch, and for each of the latter, an equally increased proportion on or below the border-line of vision.

Many minute algæ become very conspicuous by reason of their

immense numbers however; sometimes the whole surface of a lake is covered with them. For several years a little pond near Washington attracted my notice by its uniform dingy green; examination by the microscope proved regularly that it was due to presence of myriads of a very minute alga, a Staurastrum, a pretty little desmid with six radiating points of green. The Bavarian lake, the Schliersee, grew turbid under the ice of the winter before the present, acquiring a general green or blue, due, suggests Dr. Harz, to enormous quantities of the microscopic alga *Palmella uvæformis:* then the color changed under the ice to a yellow-red and at last to peach-color from the incoming of another alga, *Clathrocystis roseo-persicina,* which is said to have attacked and destroyed the other. This fittest survivor, conqueror in the battle of the algal hosts under the ice, was found lurking in wide expanses of beautiful peach color on the mud bottom of Babcock Lake here in Washington, recently drained to assure the safety of the Washington monument. The green surfaces of stagnant pools everywhere familiar, are also examples of minute algæ occurring in vast masses.

The larger species may be mounted on cards or sheets of unglazed paper as is so common with the marine algæ; or on sheets of mica for coarser microscopic examination; or preserved for the same purpose in bottles of carbolized water. My practice is, however, to preserve specimens for the microscope, large or small, in cement cells, using as a medium King's fresh-water algæ fluid; specimens of three or four years' standing still remain unchanged. Some species may be collected throughout the year, even under the ice; in the city of Washington many are constantly abundant as green coatings on trees, walls and stone steps; others live in the drinking fountains, species, as *Draparnaldia plumosa,* which exist only in pure water; others are to be sought on the damp wood work of pumps; still others in the conservatories, on damp bricks and flower-pots and in the soil. The mud of the Potomac margin contains its own species, and there the Vaucheria waves in profusion; Oscillarias, Palmellas, and other unicellular species abound; and outside of the city, springs, streams and pools are each full of their treasures, wet banks and even meadows yield their own peculiar species; and the early spring pools filled by Potomac overflows are especially the haunt of the Algæ.

And now if interest has been awakened in these minutest of the pet nurslings of nature, the next step is to collect, examine and preserve them. Do not stop at that point let me beg of you, for it is but the threshold; but seek to discover the entire life-history of the species around you. Uncounted problems of supremest interest await the verdict of those researches. Only by such work can the foundation of a true and permanent classification of the algæ be laid. Questions of far-reading importance follow regarding their relations to the fungi, and to animal life, and their ultimate part in the scale of nature. Uses the algæ may have, many and as yet unknown; but perhaps none more important will ever be discovered than their service which science already knows, that of furnishing a means by which to learn of the origin and the processes of life. The algæ as among the simplest of living things stand close to the gateway whence life first entered into the world, and invite the hope that their investigation may yield many important additions to the world's knowledge of what life is.

REVIEW OF THE PROGRESS OF NORTH AMERICAN PALÆONTOLOGY FOR THE YEAR 1887.

BY JOHN BELKNAP MARCOU.

I REGRET that, owing to the delay in the publication of the Smithsonian report for 1886, my record of North American palæontology for that year has not yet appeared, and the date of its publication is still uncertain. For this reason I again publish in the AMERICAN NATURALIST a brief review of the titles of the new works on North American palæontology, which I have collected during the year 1887, in order to give the workers in this branch of science a brief view of the work of the past year, leaving all abstracts, notes and comments to another paper, which will be published either by the Smithsonian Institution or the U. S. Geological Survey.

Truman H. Aldrich, in Jour. Cincinnati Soc. Nat. Hist., Vol.